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ABSTRACT

This guide, the second (part 2) in a set of four guides, is designed for the student interested in a vocation in electrical work, and includes two units: Unit IV--Electrical Theory, covering thirteen lessons (matter, the atom, electrical charges in the atom, rules of electric charges, electricity, atoms in an electrical conductor, electrical conductors, structure of insulating substances, insulation--what it does, safety devices--fuses and circuit breakers, light and heat from electricity, electricity produced from chemicals); and Unit V--Magnetism, covering seven lessons (magnets, magnetic poles, magnetic field, magnetic induction, electromagnetism, making a simple electromagnet, how an electromagnet operates a door bell). Each lesson includes an objective, vocabulary, information about the lesson, an assignment, and illustrations. (For the beginning units (I through III), see CE 014 109.) (SH)

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State of New Jersey
Department of Education
Division of Vocational Education

Basic Electricity

Part 2

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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Electrical Theory

Unit IV

Matter **Lesson 1**

OBJECTIVE:

When you have completed this lesson you will know what matter is.

VOCABULARY:

matter (mat'ər) – anything at all that takes up space and has weight.
liquid (lik'wid) – a kind of matter that you can pour, like water or oil.
gas (gas) – a kind of matter that you cannot see.
solid (sol'-id) – a kind of matter that is not a liquid or gas. It has its own shape.

INFORMATION:

Matter is anything that takes up space and has weight.

There are three forms of *matter*:

1. Liquids

Milk, water, and oil are liquids.

2. Gases

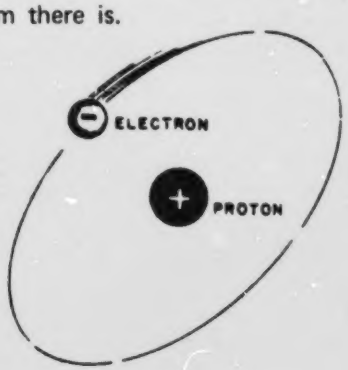
Soda has a gas *in it called carbon dioxide.*

3. Solids

All these things are solids.

All matter is made up of very, *very, VERY* tiny parts called *atoms*. They are so tiny that there are *millions* of atoms in the dot over the letter i printed here!

Below is a picture of an atom of the gas called hydrogen. This is the smallest and lightest atom there is.



A Hydrogen Atom

ASSIGNMENT:

1. Matter is anything that takes up _____ and has _____.

2. Name three forms of matter.

   1.
   2.
   3.

3. Matter is made from very, very small parts called _____.

UNIT IV – ELECTRICAL THEORY

The Atom **Lesson 2**

OBJECTIVE:

When you have completed this lesson you will know the structure of an atom.

VOCABULARY:

structure (struk'-chər) – how something is made – the way its parts go together.

orbit (ôr'-bit) – a path around something, like the path of the earth around the sun.

solar system (sō'-lər sis'-təm) – the sun, the earth, and the other heavenly bodies called the planets.

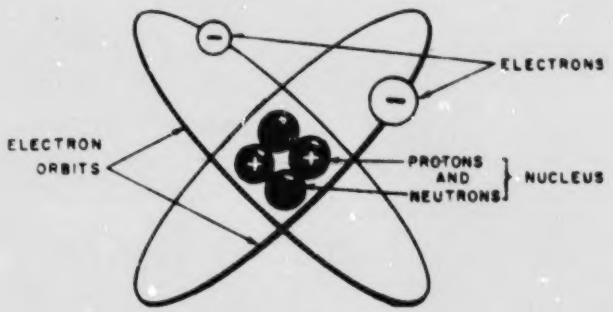
compare (kəm-pãr) – find out how things are alike and how they are different.

INFORMATION:

The atom structure is something like our solar system. At the center is a nucleus, like the sun. Rushing around the nucleus are the tiny electrons, like the earth and the other planets.

Here is a diagram of part of our solar system.

Below is a diagram of an atom. Compare it with the solar system.



Atomic Structure

Every atom is made of three parts.

1. Neutrons
2. Protons

} Together these make up the nucleus.

3. Electrons

It is the number of *protons* in an atom that makes it the kind of matter that it is – hydrogen, oxygen, iron, copper, gold, etc.

Look back at the picture of the atom structure, and find the electrons, protons, and neutrons.

ASSIGNMENT:

1. Name the three parts of an atom.

   a. _____
   b. _____ } Together make up the _____
   c. _____

2. The structure of an atom is something like the _____ system.

   a. The nucleus may be compared to the _____.

   b. The electrons may be compared to the _____.

3. The number of _____ in an atom makes it the kind of matter it is.

Electrical Charges in the Atom **Lesson 3**

OBJECTIVE:

When you have completed this lesson you will know about positive and negative charges in the atom.

You will know what an electron shell is.

You will know what a free electron is.

VOCABULARY:

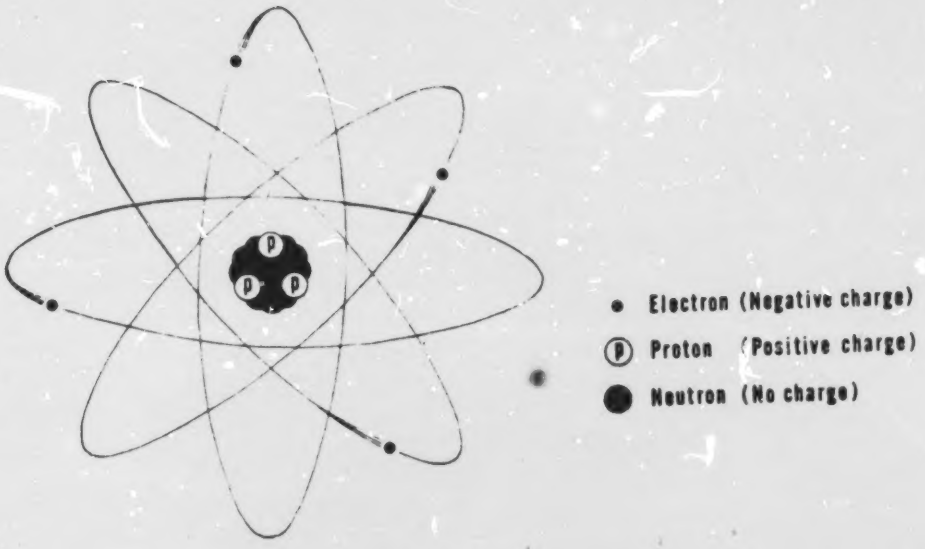
normally (nôr'-məl-i) – usually, almost always.

INFORMATION:

A *charge* is a force that "wants" to do something or go somewhere. The parts of an atom have two different kinds of charges. These are called *positive* charges and *negative* charges. We use the symbol "+" for a positive charge and "–" for a negative charge.

Anything that has the same number of positive charges and negative charges is called *neutral*.

Here is another diagram of an atom.



The parts of an atom

ELECTRON – So light in weight that it is almost weightless. Electrons continually travel around the nucleus in orbits called *shells*. An electron has a *negative* (–) charge.

PROTON – Much heavier than the electron. Found in the center, or nucleus of the atom. A proton has a *positive* (+) charge.

NEUTRON – Also found in the center of the atom. It is about as heavy as a proton. It is *electrically neutral* – it has no charge.

NUCLEUS – The *nucleus* is at the center of the atom. It holds the *protons* and *neutrons*. Because the protons have a positive charge, the nucleus has a positive charge.

Atoms normally have the same number of electrons as protons. They have the same number of negative charges as positive charges. They are *electrically neutral*.

Atoms of some types of matter have electrons that are easy to knock out of their shells. These electrons are called *free electrons*.

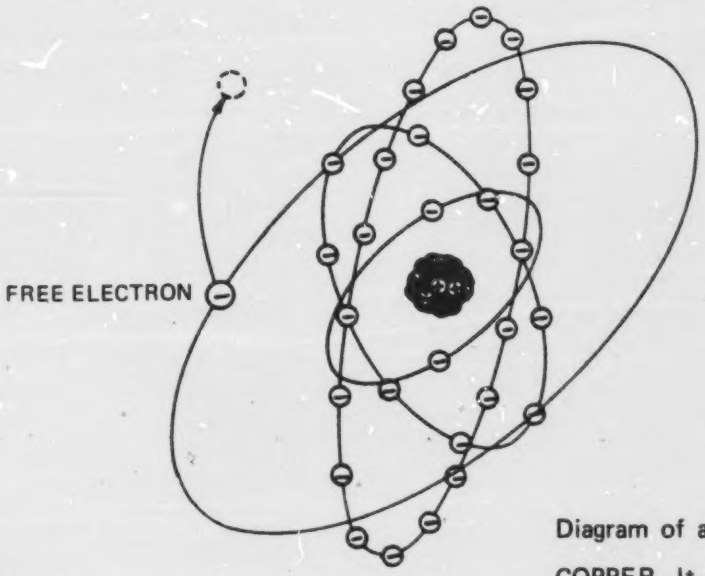


Diagram of an atom of COPPER. It has 29 electrons including a single one in the outside shell.

ASSIGNMENT:

1. The electron has a _____ charge.

2. The proton has a _____ charge.

3. The neutron is electrically _____.

4. Electrons are _____ in weight and travel around the _____.

5. Protons are _____ in weight and stay in the _____ of the atom.

6. Electrons travel around the nucleus in orbits called _____.

7. Atoms are normally electrically _____.

8. An electron that is easy to knock out of its shell is called a _____ electron.

Rules of Electric Charges **Lesson 4**

OBJECTIVE:

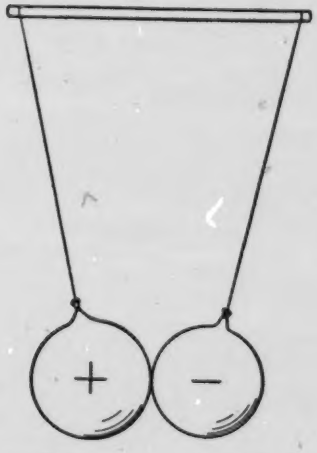
When you have completed this lesson you will know the three rules of electrical charges.

VOCABULARY:

like (līk) – alike; the same.
unlike (un'-līk') – not the same; different
repel (ri-pel') – push away from

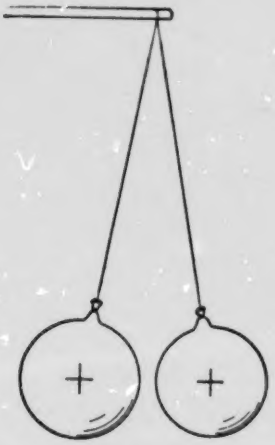
INFORMATION:

Rule 1. Things having *unlike* charges *attract* each other. ***See illustration below.***



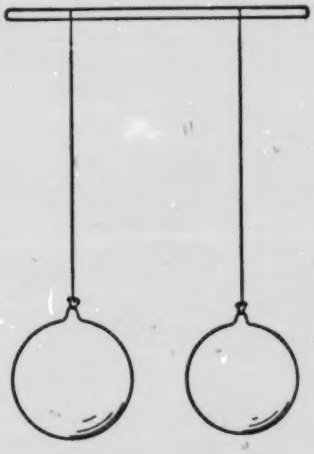
Unlike charges attract each other.

Rule 2. Things having *like* charges *repel* each other. *See illustration below.*



Like charges repel each other.

Rule 3. Things having *no charge* do not attract or repel. They are *electrically neutral. See illustration below.*



Electrically Neutral

In an atom, the nucleus has a positive charge. It attracts electrons.

The electrons have negative charges. They repel other electrons.

ASSIGNMENT:

1. Fill in *"attract"* or *"repel"*:

a. Two positive charges _____ each other.

b. Two negative charges _____ each other.

c. Something with a positive charge _____s something with a negative charge.

d. Electrons _____ each other.

e. A proton _____s an electron.

2. Things having no charge are called _____ _____.

3. An atom with 29 protons and 29 electrons is _____.

   a. Positively charged
   b. Negatively charged
   c. Electrically neutral

What Is Electricity? **Lesson 5**

OBJECTIVE:

When you have completed this lesson you will know how electric current flows.

VOCABULARY:

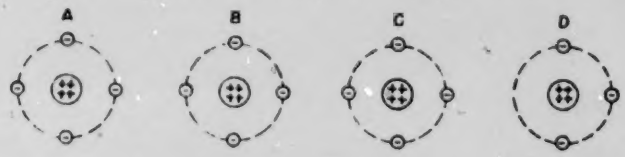
current (kur'ant) – a flow of something, like water in a river, or electricity in a wire.

INFORMATION:

Below is a diagram of four normal atoms. You can see that eacn atom has four electrons (four negative charges). Each atom also has four protons in its nucleus (four positive charges). The atoms are electrically neutral.

Electrically Neutral Atoms

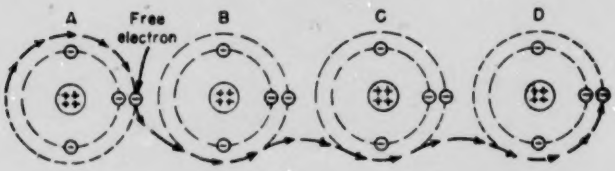
Below is a picture of four atoms, but with this difference – one atom has lost an electron. See atom D – it has only three electrons. Now it is *not* electrically neutral. It has four positive charges and only three negative charges. So it is not neutral any more. It now has a *positive charge.*



Atom D now has a positive charge.

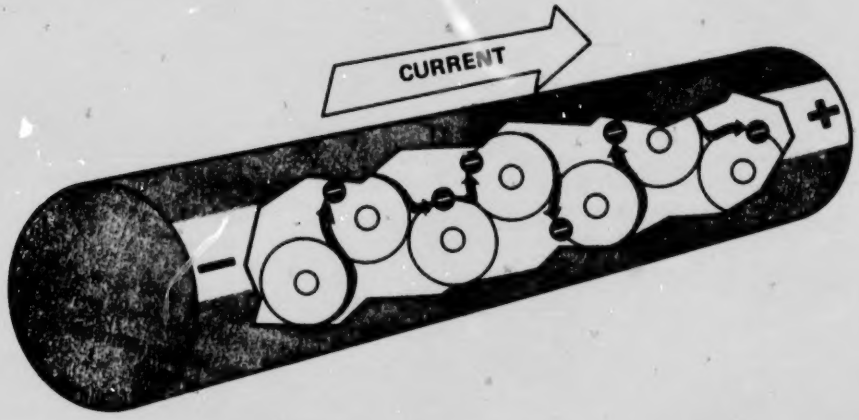
Remember that *unlike* charges *attract* each other. The positively charged Atom D will attract a free electron from Atom C. This leaves Atom C with only three electrons. It gets a positive charge. It will attract a free electron from Atom B, and so on. This is called the movement of free electrons. *See the illustration below.* Follow the arrow of free electrons moving from one atom to the other. This is the flow of electric current.

Electric current is the flow of free electrons from one atom to another.



Movement of free electrons

Remember, these electrons move only from one atom to another. But the electric current can move many feet, yards, or miles in a wire.



ASSIGNMENT:

1. Things having unlike charges _____ each other.

2. Like charges _____ each other.

3. If two or more atoms have the same number of electrons and protons they are electrically _____.

4. Free _____ can move from one _____ to another.

5. Electric _____ is the flow of free electrons.

Atoms in an Electrical Conductor — Lesson 6

OBJECTIVE:

When you have completed this lesson, you will know what metals make the best electrical conductors.

You will know that electrons need a force to make them move from one atom to another.

You will know what happens in an electric circuit.

VOCABULARY:

conductor (kən-duk′-tər) – something that can carry an electric current.

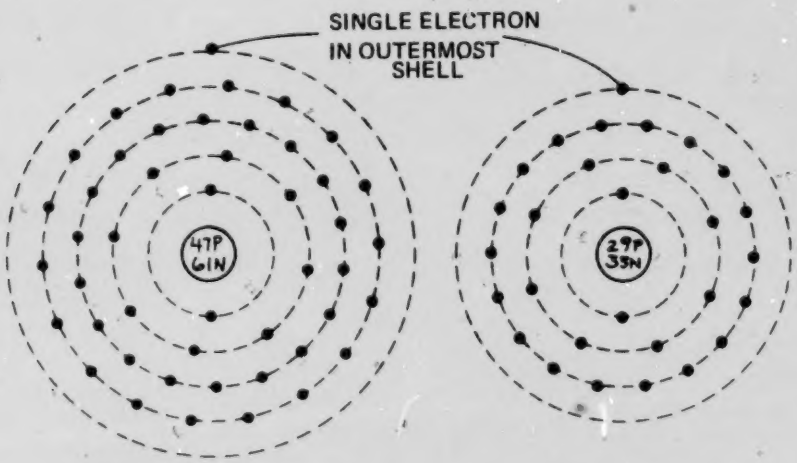
terminal (tėr′-mi-nəl) – a place for connecting a wire.

filament (fil′-ə-mənt) – a very thin thread, or a very thin wire.

circuit (sėr′-kit) – the path in which electricity flows.

INFORMATION:

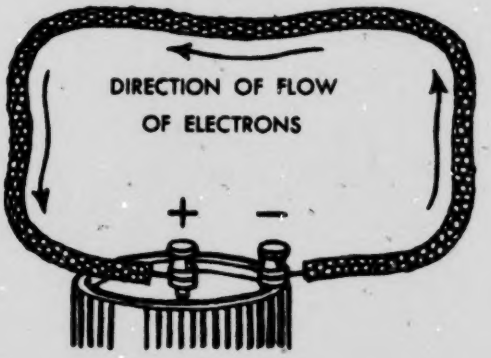
The atoms of a metal such as **copper** have a single free electron in the outside shell. So do the atoms of the metal **silver**. These metals make the best electrical conductors. The diagram below shows the structure of a silver atom and a copper atom.



SILVER ATOM COPPER ATOM

To make free electrons move from atom to atom, we need *force*. This force can be a battery.

A battery has a positive terminal and a negative terminal. If you attach a conductor (wire) to both terminals, what happens?

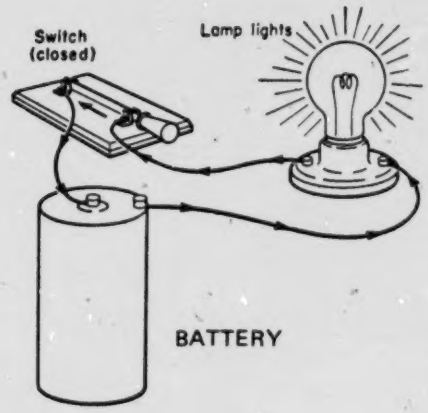


The positive (+) terminal *attracts* free electrons (–) from that end of the wire. The negative (–) terminal *repels* free electrons (–) at the other end of the wire. We saw in the last lesson what happens. Free electrons are pulled from one atom to another. An electric current flows through the conductor.

Now let us attach the copper conductor (wire) to the force (battery) and also to a lamp bulb and a switch and back to the battery. (See next page.)

When the switch is closed, the battery forces electrons through the wires, through the lamp filament and through the metal of the switch. The electrons heat the filament in the bulb and make it glow.

The electrons will continue to flow until you open the switch, or until the battery dies. Remember – electricity will not flow unless you have a *complete circuit.* If you break the circuit in any place, the current will stop.



Electrons flow through a wire at a speed of a few inches or feet in a second. But the electrical energy (or "push") travels through that wire at a speed of 186,000 *miles per second*!

The best conductors of electricity are listed in order below.

1. Silver
2. Copper
3. Gold
4. Aluminum
5. Zinc
6. Nickel
7. Iron
8. Lead

ASSIGNMENT:

1. Atoms with free electrons make the best electrical _____.

2. Name 5 metals that make good electrical conductors.

   1. 4.

   2. 5.

   3.

3. The speed of electric current is 186,000 _____ per second.
   (feet, yards, miles)

4. To make electrons move from one atom to another, we need a _____.

5. Electricity will only flow in a _____ circuit.

UNIT IV – ELECTRICAL THEORY

Electrical Conductors **Lesson 7**

OBJECTIVE:

When you have completed this lesson, you will be able to:

1. Define conductor.
2. Know the difference between solid and stranded conductors; large- and small-size conductors.

VOCABULARY:

aluminum (ə-lü'-mi-nəm) – a silver-white light-weight metal.

copper (kop'-er) – a reddish metal, easy to bend and solder.

strand – a small thread or wire. Many strands are put together to make a rope or a wire.

INFORMATION:

The word *"conductor"* can mean more than one thing. A *conductor* can be a person on a train who takes your ticket.

In this lesson, a *conductor* is a wire that carries electric current.

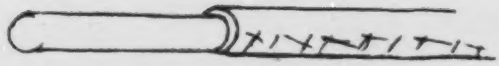
TRAIN CONDUCTOR

ELECTRICAL CONDUCTOR

This kind of conductor.

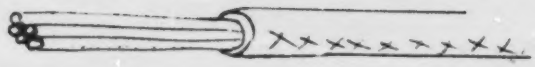
Not him.

Some conductors are solid.



SOLID CONDUCTOR

Some conductors are stranded.



STRANDED CONDUCTOR

All electric conductors are made of metal. The two important metals are:

1. copper
2. aluminum

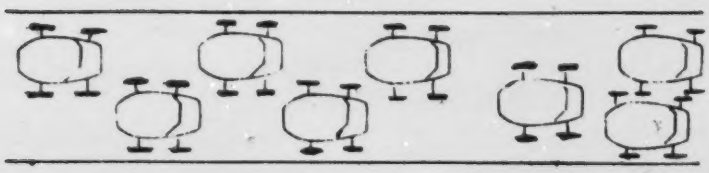
Copper is used more than aluminum.

Silver is the best conductor of all, but it is too expensive for most uses.

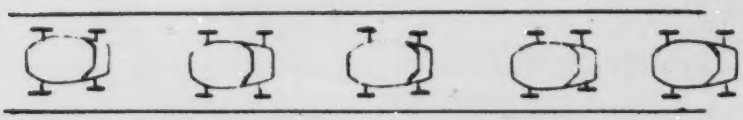
An electric conductor is like a road.

The electrons are like cars.

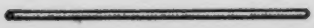
A large road will let more cars move.



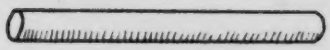
A small road will let fewer cars move.



Electrical conductors are made in different sizes.



SMALL CONDUCTOR



LARGE CONDUCTOR

A large conductor will let more electric current move.

A small conductor will let less electric current move.

ASSIGNMENT:

1. Another name for an electric wire is a _____.

2. Name two kinds of metal used for electrical conductors.

   a. _____

   b. _____

3. Conductors may be solid or _____.

4. A large wire will let _____ electric current move.

5. A small wire will let _____ electric current move.

Structure of Insulating Substances **Lesson 8**

OBJECTIVE:

When you have completed this lesson you will know what an *insulator* is and what an insulator does.

VOCABULARY:

insulate (in'-sal-āt) – protect from electricity.

substance (sub' stans) – any kind of matter or material.

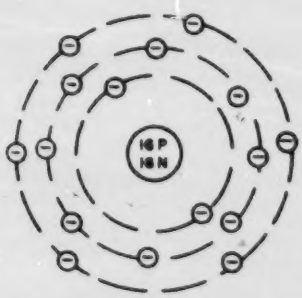
chemist (kem'-ist) – a person who works with different kinds of matter, making new substances out of different kinds of atoms.

compound (kom'-pound) – a substance made up of two or more kinds of atoms. Most substances around us are compounds – salt, sugar, wood, plastics, paint, cloth, glass, etc., etc.

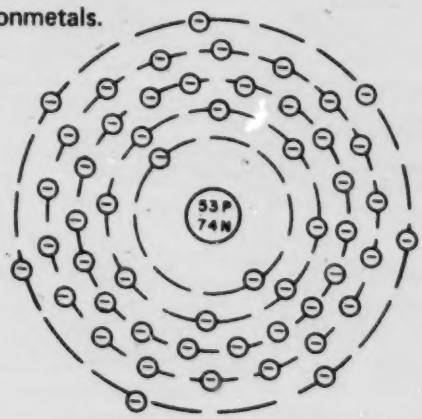
shock (shok) – a sudden, bad hurt.

INFORMATION:

Some kinds of matter are not good conductors of electricity. Their atoms have 5 or 6 or 7 electrons in their outside shells. They are all non-metals. Below are diagrams of two nonmetals.



ATOM OF SULPHUR



ATOM OF IODINE

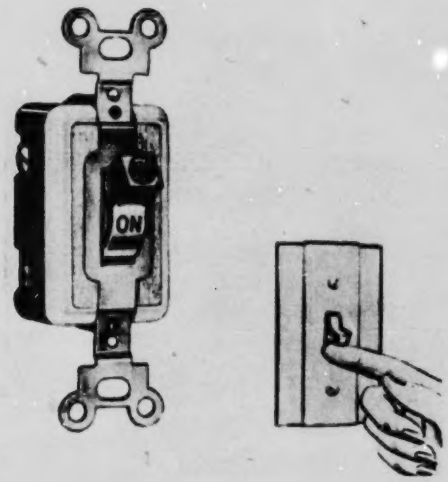
These atoms cannot be forced to give up electrons to pass along an electric current. They are insulators.

Chemists have learned how to join different kinds of atoms together to make new substances. These joined atoms are called *compounds*.

Atoms like the ones on page 115 are easy to join with certain other kinds of atoms. The kinds they "like best" to join are those that will make eight electrons in the new outside shell. Compounds with eight electrons in the outside shell make very good insulators.

Insulation protects you from electric shocks.

Below is a picture of a Bakelite toggle switch and cover plate. They protect a person from a shock.



Below is a list of insulating materials. They are all compounds of different kinds of atoms. Current will not flow through these materials.

1. Shellac
2. Rubber
3. Porcelain
4. Glass
5. Dry paper
6. Wood
7. Bakelite

ASSIGNMENT:

1. Insulating substances do not give up _____ to pass along an _____ _____.

2. All insulators are _____.

   a. conductors
   b. shells
   c. nonmetals
   d. electrons

3. Insulation protects you from _____ _____.

4. Electric current will not flow through _____.

   a. copper
   b. aluminum
   c. rubber
   d. silver

5. Name 4 types of insulating substances.

   1.

   2.

   3.

   4.

Insulation – What It Does **Lesson 9**

OBJECTIVE:

When you have completed this lesson, you should be able to tell what insulation does.

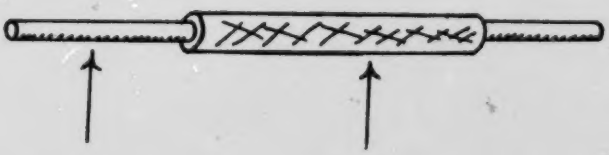
VOCABULARY:

bare (bār) – with no covering.

short circuit – a short path that the electrons take when there is no insulation to prevent it (stop it).

INFORMATION:

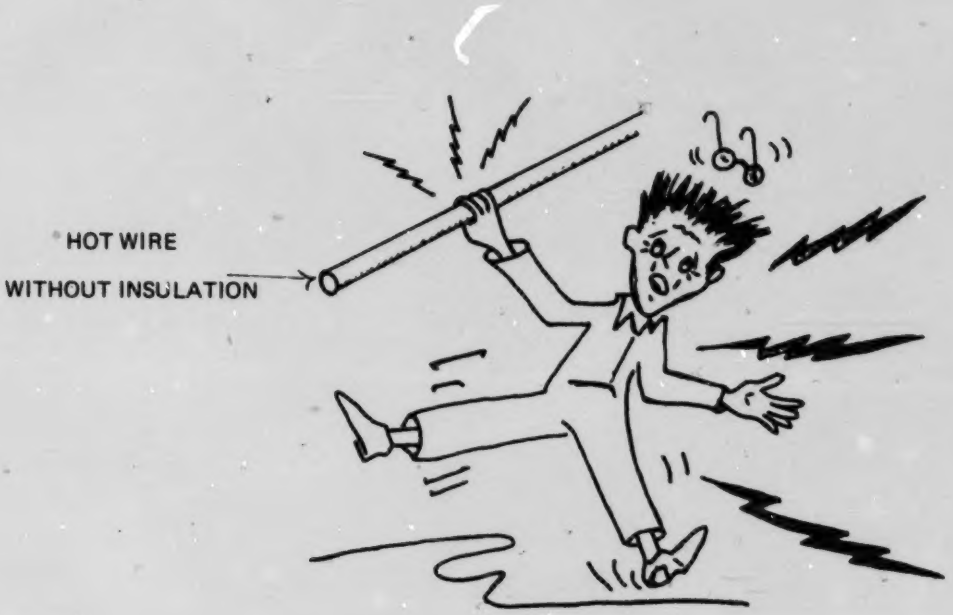
Insulation on electric wires protects you from an *electric shock*.



A wire without insulation is a *bare wire.*

If electric current is moving through a wire, it is called a *hot wire.*

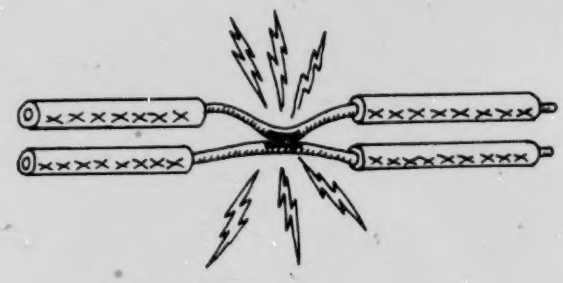
If you *touch a bare hot wire,* you will look like this guy!



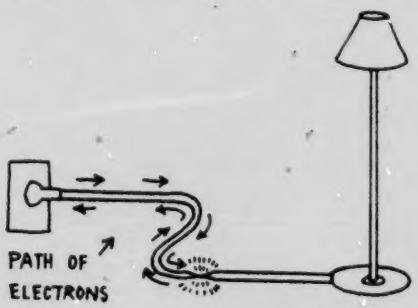
THIS MAN IS GETTING AN ELECTRIC SHOCK.

Another reason insulation must be on a wire is to prevent a *short circuit.*

A *short circuit* is two bare wires touching each other.



Sometimes insulation gets old and worn out. If bare wires touch each other, the electrons do not do their "work" (like going through this lamp and lighting it.)



The electrons rush around the short circuit. The wires get very hot. You could have a fire.

ASSIGNMENT:

1. Insulation will protect you from an _____ _____.

2. A wire without insulation is a _____ wire.

3. Two bare wires that touch each other cause a _____ _____.

4. A short circuit can start a _____.

Safety Devices (Fuses and Circuit Breakers) **Lesson 10**

OBJECTIVE:

When you have completed this lesson you will know how a fuse or circuit breaker protects your home and equipment from serious damage.

You will know how to protect your home with the right size safety devices.

VOCABULARY:

device (di-vīs′) – a small tool or other thing made for a special purpose.

equipment (i-kwip′-mənt) – useful objects. Electrical equipment includes irons, toasters, washers, electric drills, electric saws, etc.

damage (dam′ij) – harm.

blow (a fuse) – open a circuit by melting some metal in the fuse. A blown fuse must be replaced – it cannot be used again.

trip (a circuit breaker) – open a circuit by moving a switch. A tripped circuit breaker can be reset.

system (sis′-təm) – a great many things, all part of a whole, like a school system, a digestive system, an electrical system.

vaporize (vā′-pər-īz) – change from a solid to a gas.

automatic (ô-tə-mat′-ik) – acting by itself.

INFORMATION:

Fuses and *circuit breakers* are safety devices. They are put into the different electric circuits. A *blown* fuse or a *tripped* circuit breaker is telling you that something is wrong in the circuit. By blowing it is *protecting* the electrical system from damage or fire.

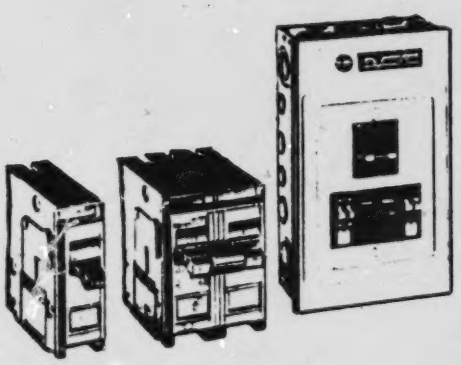
Below are pictures showing different types of fuses and circuit breakers.

(A)

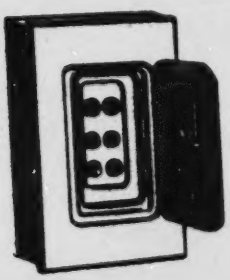
PLUG FUSE

(B)

CARTRIDGE FUSE



CIRCUIT BREAKERS



FUSE BOX

There are three main reasons why fuses blow or circuit breakers trip.

1. LOOSE CONNECTION

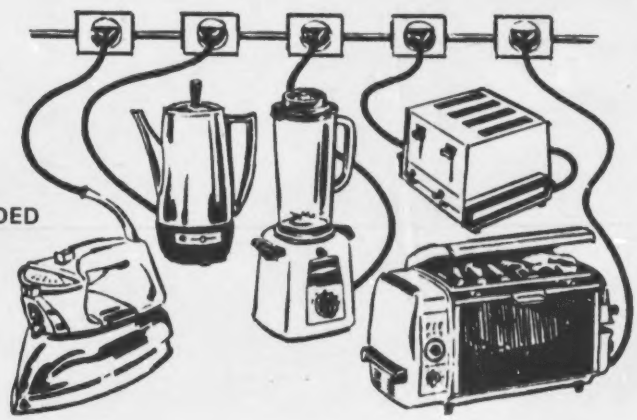
LOOSE CONNECTION.
Screw not tight against wire.

The screw is not *tight* against the wire. The wire *heats* up and the fuse blows or the breaker trips.

2. SHORT CIRCUIT

This is caused when the *hot* wire touches the *ground* wire. A fire could start if the right size fuse or breaker is not protecting the circuit.

3. OVERLOADED CIRCUIT



OVERLOADED CIRCUIT

This happens when too many appliances are being used at the same time on one circuit. The wire heats up and blows the fuse.

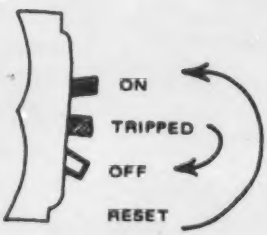
The picture below shows how fuses and circuit breakers look when something has gone wrong with the electrical system in your home.

This is a standard plug-type fuse. The current passes through the metal strip across the fuse.

Fuse blown by short circuit. *Metal strip quickly gets so hot that it vaporizes. Fuse window gets dark.*

Fuse blown by overload. *Metal strip overheats and melts at the weakest point, breaking flow of current to circuit. Fuse window remains clear.*

Circuit breaker switch. When overloads or shorts occur, it will switch off automatically. Reset it immediately after correcting trouble.



CIRCUIT BREAKER

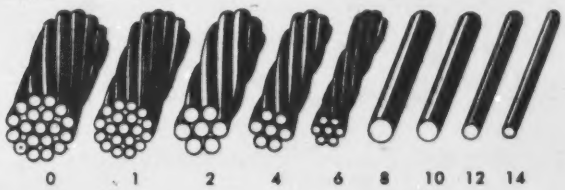
If the fuse doesn't blow or the circuit breaker doesn't trip when you have an electrical problem, it means that the safety device is the wrong size for the circuit. It lets too many amperes of current go through the wires. You could have a fire in your home.

Below is a fuse—circuit breaker chart that shows the right size safety device for different sizes of copper wire.

AMPERE SIZES OF COPPER WIRES

Wire size	In Conduit or Cable		In Free Air		Weather-proof Wire
	Type RHW* THW*	Type TW, R*	Type RHW* THW*	Type TW, R*	
14	15	15	20	20	30
12	20	20	25	25	40
10	30	30	40	40	55
8	45	40	65	55	70
6	65	55	95	80	100
4	85	70	125	105	130
3	100	80	145	120	150
2	115	95	170	140	175
1	130	110	195	165	205
0	150	125	230	195	235
00	175	145	265	225	275
000	200	165	310	260	320

*Types "RHW," "THW," "TW," or "R" are identified by markings on outer cover



Actual size of copper conductors. Note the larger the gauge number the smaller the diameter of the wire.

ASSIGNMENT:

1. Fuses and circuit breakers are _____ _____.

2. There are 3 main reasons why fuses and breakers blow or trip. Name them.

   1.

   2.

   3.

3. You could have a fire in your home if the fuse lets too _____ amperes go through the circuit. *(few, many, same)*

4. What size amp fuse will protect the following size wires?

T.H.W. Wire Size	Fuse or breaker size
14	_____
12	_____
10	_____
8	_____
6	_____

5. Find out the ampere sizes of the fuses or circuit breakers that protect your own home.

UNIT IV – ELECTRICAL THEORY

Light from Electricity **Lesson 11**

OBJECTIVE:

When you have completed this lesson, you will be able to describe how we get light from electricity.

VOCABULARY:

filament (fil′-ə-mənt) – the very thin wire that gives off light in an electric light bulb.

glow (glō) – to shine brightly; give light.

incandescent (in-can-des′ənt) – glowing white hot.

produce (prə-düs′) – to make; to bring into existence, to create.

INFORMATION:

Light is produced when electric current moves through the filament in a bulb.

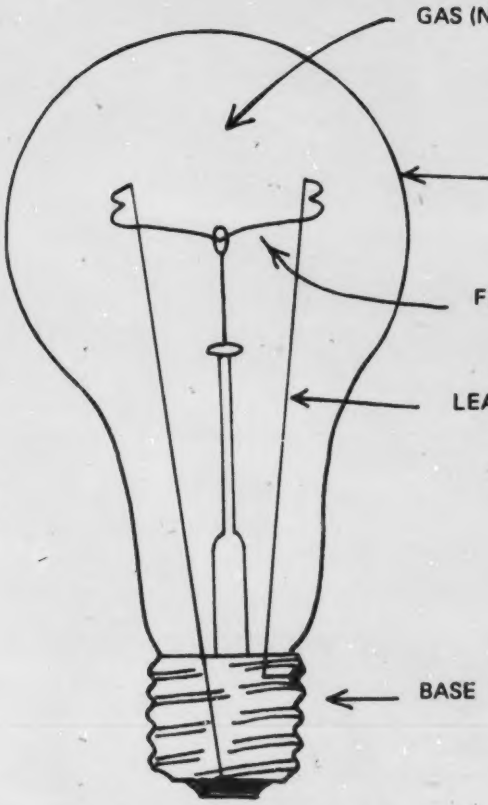
The electric current makes a filament so hot that it glows. The white-hot glow is light.

Good light is important. Use it!

Good light is important. Use it!

This is a light bulb or *incandescent light.*

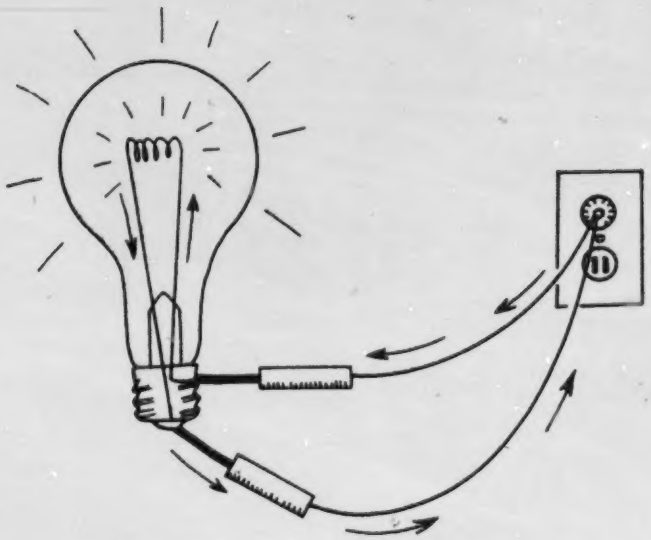
Incandescent means *glowing white hot.*



The gas inside the bulb makes the bulb last longer.

INCANDESCENT LIGHT BULB

The wire in the bulb is a poor conductor of electricity. Most poor conductors get very hot when current goes through them. They get so hot that they glow. That is what makes the bulb give light.



This shows a light bulb connected to the electric circuit in a house by testing equipment. It is giving off light.

ASSIGNMENT:

1. Electric current makes the _____ glow white hot.

2. What is another name for a bulb? _____

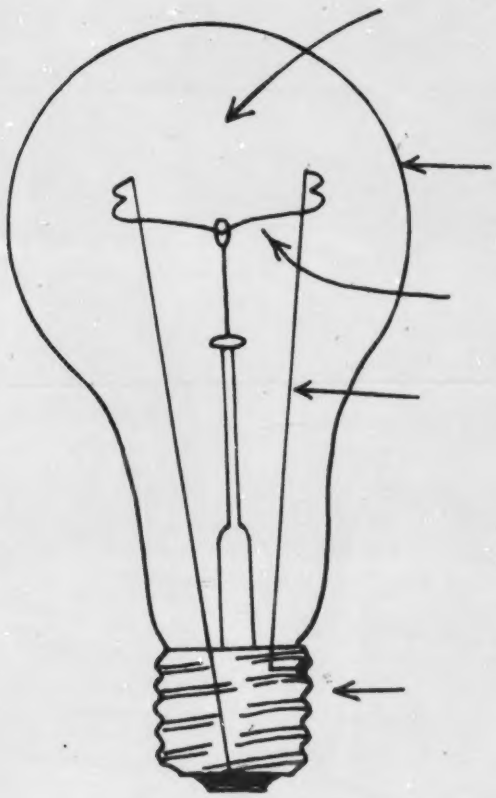
_____.

3. Gas (nitrogen and argon) is put into the bulb to make it _____

_____.

4. Incandescent means g_____ing w_____ h_____.

5. Name the parts:



Heat from Electricity **Lesson 12**

OBJECTIVE:

When you have completed this lesson, you will be able to explain how we get heat from electricity.

VOCABULARY:

element (el'-ə- mənt) – One of the parts that something is made from.
nichrome (nī'-krōm) – A special metal used for heating by electricity.
appliance (ə-plī'-əns) – A small machine used to do a certain special thing.

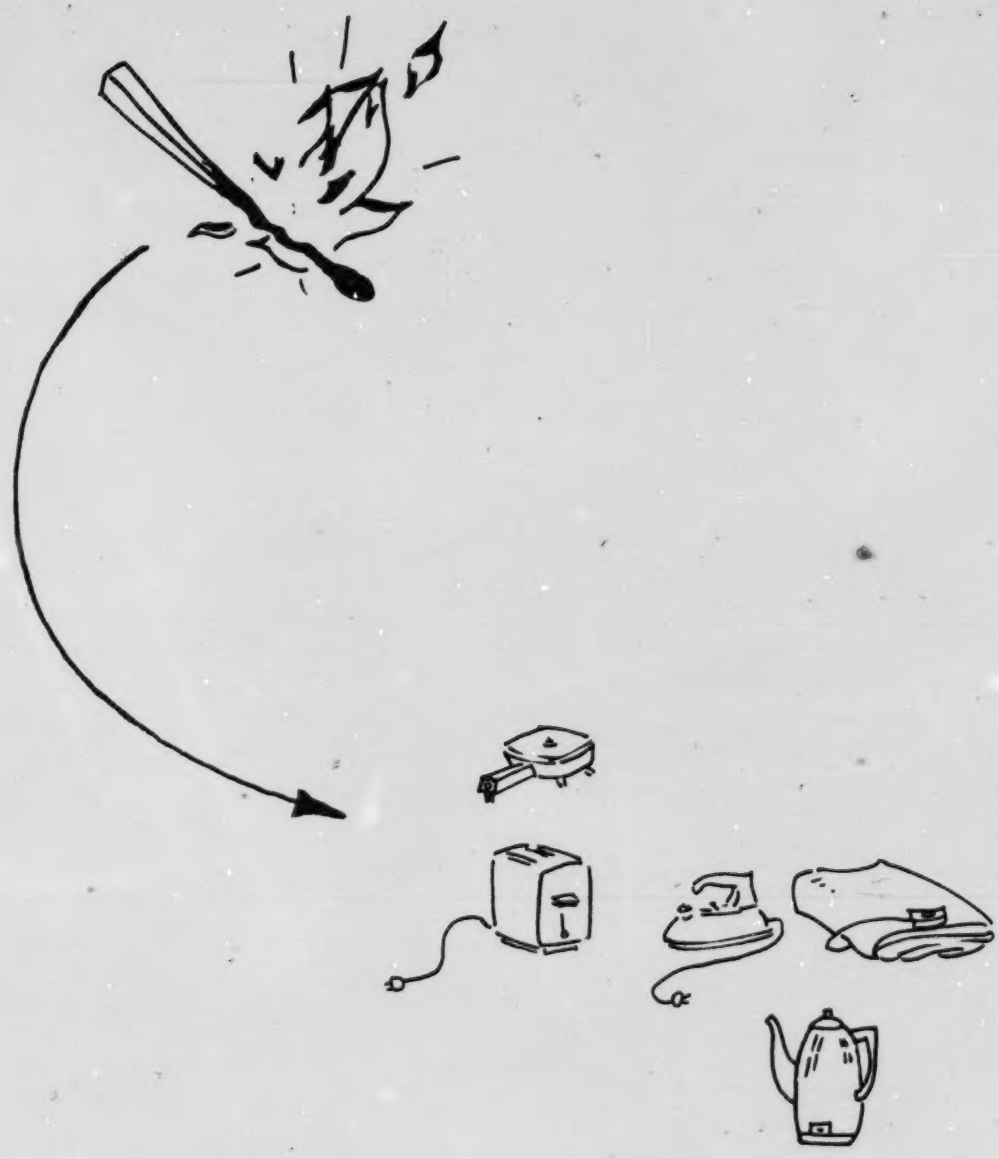
INFORMATION:

We get heat from electricity when we plug in an electric toaster.

Special wire in the toaster is used for the heating element. The special wire is called nichrome wire. Nichrome wire is made from two kinds of metal:

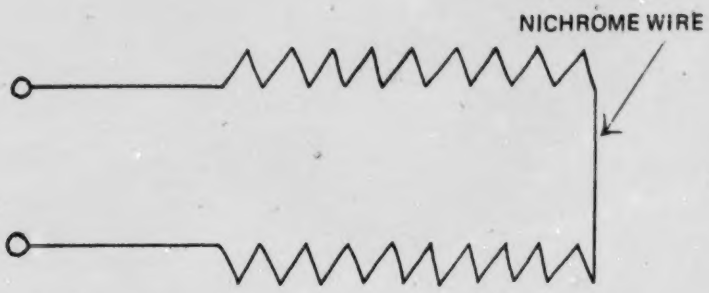
1. nickel
2. chromium

Nichrome wire is a poor conductor of electricity. When an electric current goes through it, it gets very hot. That is why it is used in appliances to give heat.



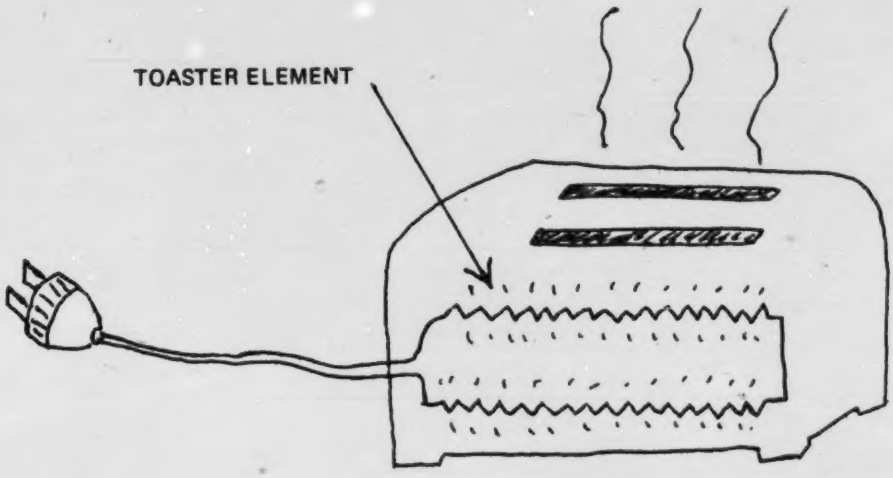
A match gives heat by burning.

These appliances give heat from electricity.



This is a symbol for a heating element.

We put the heating element in a toaster.



The plug connects the toaster element to an electrical circuit in the house.

ASSIGNMENT:

1. What is the name of the special wire used for heating in a toaster? _____

2. Nichrome wire is made from two metals. What are they?

   1. _____

   2. _____

3. List some other appliances that give heat from electricity.

   1. toaster _____

   2. _____

   3. _____

   4. _____

   5. _____

Electricity Produced from Chemicals (Battery) **Lesson 13**

OBJECTIVE:

When you have completed this lesson, you will be able to describe how electricity is produced by chemical action in a battery.

VOCABULARY:

chemical (kem′-i-kəl) – any substance that can be used to help make other substances, or to produce certain actions. (Examples – acids and salts are chemicals).

action (ak′shən) – doing something.

produce (prə-düs′) – make; supply; bring about.

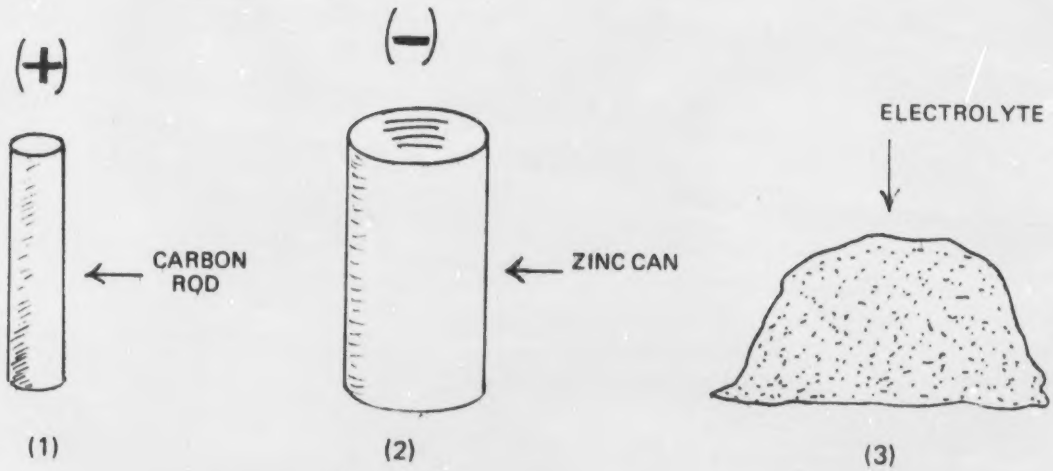
pole (pōl) – a place on a battery where electrons move in (positive pole [+]) or out (negative pole [–]). On a battery, a pole is a terminal.

INFORMATION:

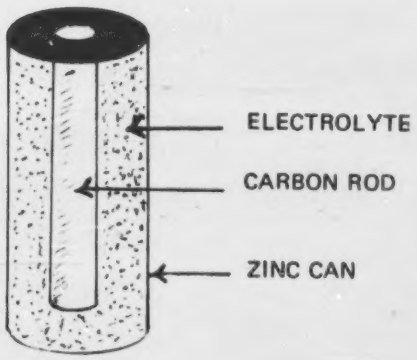
You know that a flashlight uses batteries to light the bulb. Batteries produce electricity. They do this by a chemical action.

Study the following drawings, and read how a battery can produce electricity by a chemical action.

A battery has three parts.



Put them together and you have a battery.



BATTERY

The electrolyte (i-lek′-trə-līt) is a chemical.

The electrolyte is made from an acid called sal ammoniac paste.

The electrolyte or acid "eats away" the zinc can and produces a *chemical action.*

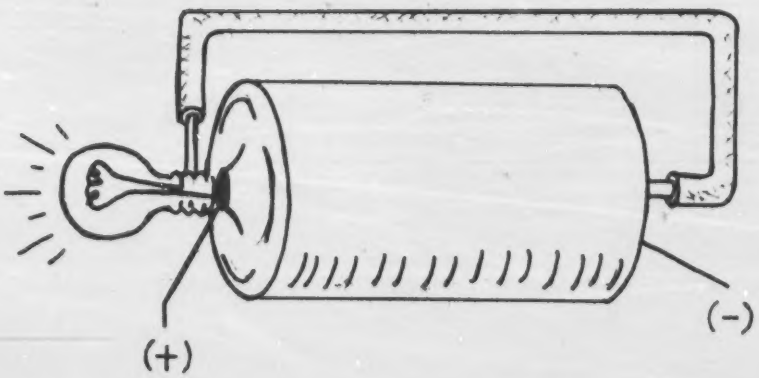
The zinc can gets extra electrons. The can gets a *negative charge.* The can becomes the *negative pole (–)* of the battery.

The carbon rod loses electrons. The rod gets a *positive charge.* The rod becomes the *positive pole (+)* of the battery.

The can has too many electrons. The rod does not have enough electrons. If you connect the can and the rod with a conductor, an electric current will flow.

The battery has produced a *voltage* – a force that makes electricity.

This battery is producing electricity for the bulb.



SAFETY TIPS

1. Be careful of that battery.

2. Don't get acid on your skin.

3. If acid gets on your skin, wash it off fast.

4. Don't get acid on your clothes; it will "eat" holes in them.

5. If acid gets on your clothes, wash them in baking soda and water.

ASSIGNMENT:

1. List the 3 parts of a battery.

   1. _____

   2. _____

   3. _____

2. Batteries produce electricity by a _____.

   1. flashlight

   2. zinc can

   3. chemical action

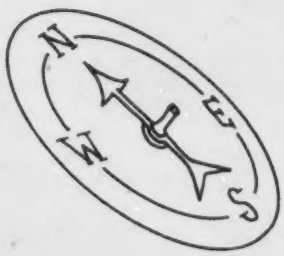
   4. carbon rod

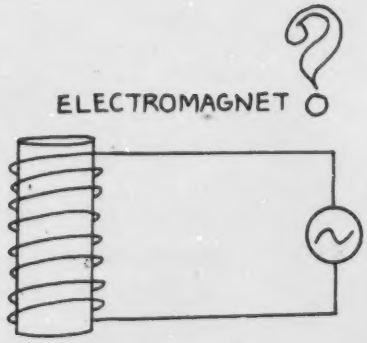
3. The carbon rod is the _____ pole.

4. The zinc can is the _____ pole.

5. The electrolyte is made from _____ _____ paste.

UNIT V





MAGNETISM

UNIT V – MAGNETISM

What Is a Magnet? **Lesson 1**

OBJECTIVE:

When you have completed this lesson, you will know what a magnet is.

You will know the difference between a natural and an artificial magnet.

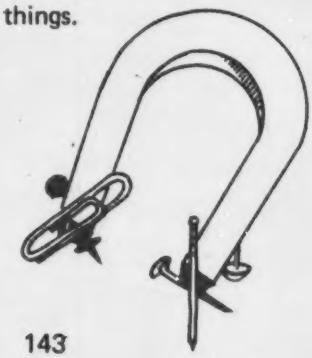
You will know the difference between a permanent and a temporary magnet.

VOCABULARY:

natural (nach′-ə- rəl) – produced without the help of any people.
artificial (är-ti-fish′-əl) – produced by people.
magnetize (mag′-nə-tīz) – change something into a magnet.
temporary (tem′-pə-rər-i) – lasting for a short time.
permanent (pėr′-mə-nənt) – lasting for a very long time.
stroke (strōk) – move gently with the hand.
bar (bär) – something smooth and even and longer than it is wide.

INFORMATION:

Have you ever played with a magnet? A magnet will attract certain things, and it is fun to test it on things.

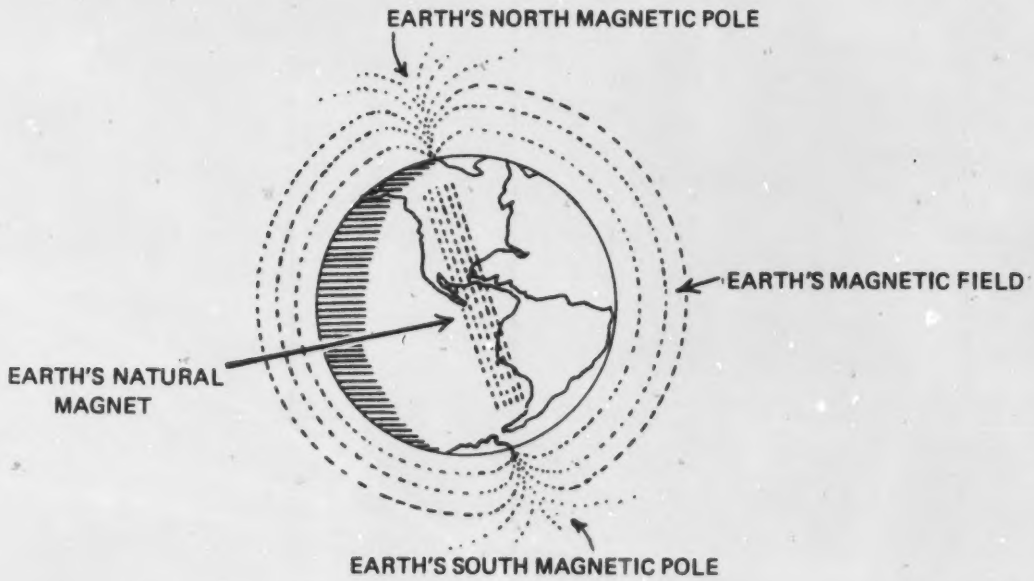


A magnet will pick up things that have iron or nickel or cobalt in them. These three metals are the only naturally magnetic substances.

A *lodestone* is a natural magnet. It is a form of iron ore. Iron ore looks like a rock.

Lodestone is mined from the earth we live on, the same way coal is mined. It is not a very strong magnet and has very little use today.

Our earth itself acts as though it has a huge bar magnet through it.



EARTH

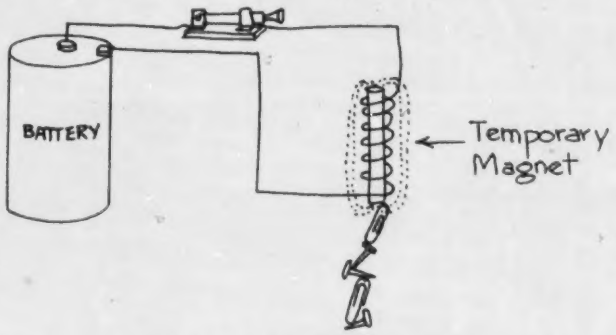
Artificial magnets are manufactured. They can be made much stronger than lodestones.

Artificial magnets are either *temporary* or *permanent*.

A temporary magnet will lose its strength as soon as the magnetizing force is stopped.

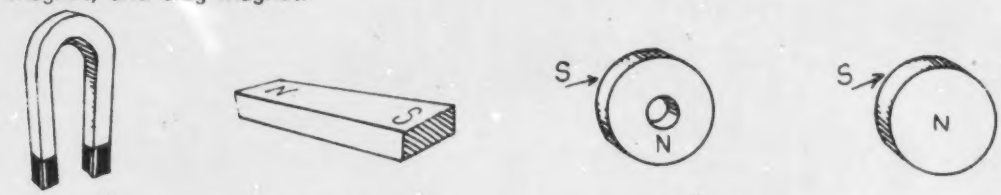
You can make a temporary magnet by stroking an iron bar with a permanent magnet. Stroke in one direction only.

You can make a temporary magnet by wrapping a bar of iron with insulated wire and connecting it to a battery. See below.



Permanent magnets are made from steel, iron, nickel, cobalt, and compounds of these metals. A permanent magnet will stay magnetized for a very long time.

Examples of permanent magnets are the horseshoe magnet, bar magnet, ring magnet, and slug magnet.



PERMANENT MAGNETS

ASSIGNMENT:

1. Natural magnets are called: _____

   a. magnetos
   b. lodestones
   c. artificial magnets
   d. temporary magnets

2. The earth is a _____ magnet.

   a. lodestone
   b. temporary magnet
   c. natural magnet
   d. manufactured magnet

3. Name two things used to make artificial magnets.

   a. _____

   b. _____

4. Name four kinds of permanent magnets.

   1. _____ 3. _____

   2. _____ 4. _____

5. You can make a temporary magnet by wrapping a bar of _____ with insulated _____ and connecting it to a battery.

Magnetic Poles **Lesson 2**

OBJECTIVE:

When you have completed this lesson you will know that magnets have two poles – a *south pole* and a *north pole*. You will learn how to find out which pole is north and which pole is south.

You will know that unlike poles of two magnets attract each other and like poles repel each other.

VOCABULARY:

pole (pōl) – one end of something that has a force opposite the force at the other end.

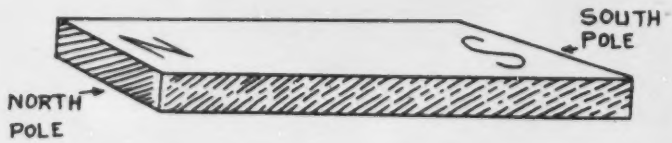
opposite (op′-ə-zit) – as different as can be.

rotate (rō-tāt′) – turn in a circle.

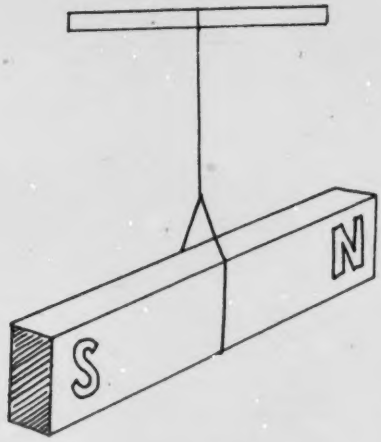
like (līk) – the same.

unlike (un′-līk) – different; opposite

INFORMATION:

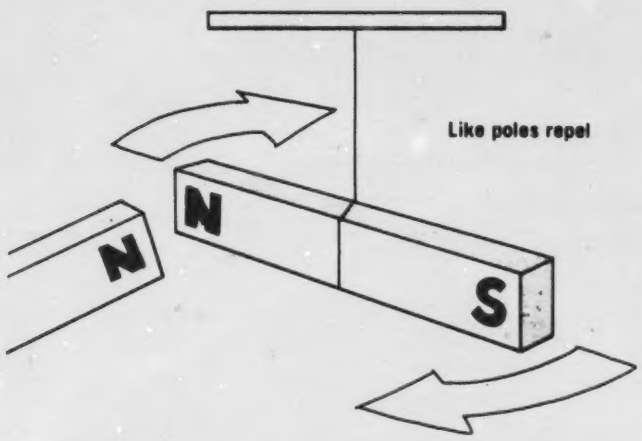


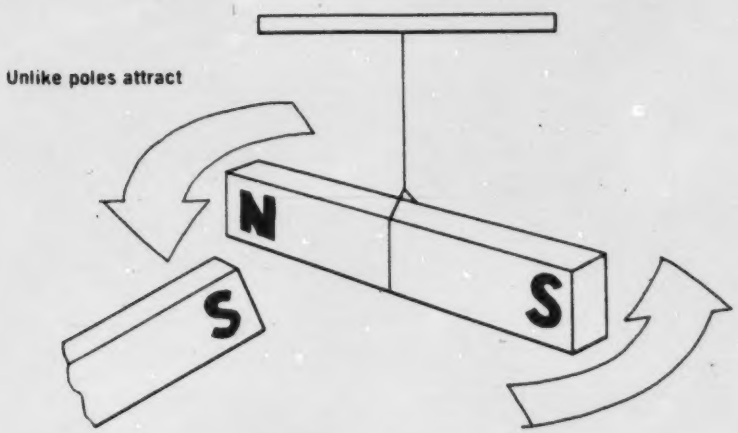
If you hang a bar magnet from a string and let it rotate (turn) freely, the magnet will rotate until one end points to the earth's north magnetic pole. We call this end of the magnet the *north pole of the magnet.* The other end is the *south pole of the magnet.*



A *compass* needle is a small permanent magnet. It is free to rotate. You can use a compass to tell direction, because it will always point to the north.

The basic law of magnetism is: *like magnetic poles repel each other and unlike magnetic poles attract each other.* See below.





ASSIGNMENT:

1. A north pole _____ a north pole.
   (repels, attracts)

2. A north pole _____ a south pole.
   (repels, attracts)

3. A south pole _____ a south pole.
   (repels, attracts)

4. A south pole _____ a north pole.
   (repels, attracts)

5. If a magnet hangs so it can rotate freely, the north end of the magnet will point to the _____ *(north, south)* magnetic pole of the _____.

UNIT V – MAGNETISM

Magnetic Field **Lesson 3**

OBJECTIVE:

When you have completed this lesson you will know what a magnetic field is and how the lines of force are arranged.

VOCABULARY:

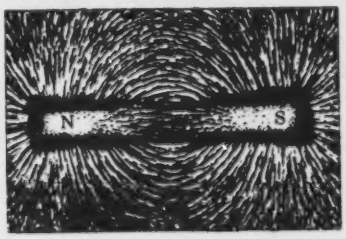
flux (fluks) – a flowing.

resistance (ri-ziz′-tans) – something that holds back a force. "Path of least resistance" is the way that's easiest for a force to travel.

INFORMATION:

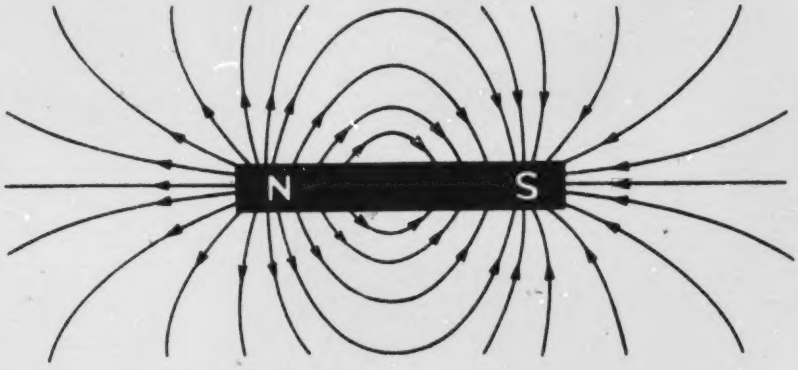
We know that a magnet will pick up certain things and hold them. There is a force around every magnet. It is strongest at the ends of the magnet. It is called a *magnetic field.*

A magnetic field is made up of magnetic *lines of force.* The picture below shows how the lines of force are arranged around a magnet. This is a picture of tiny bits of iron sprinkled on a heavy paper that was lying on a magnet.



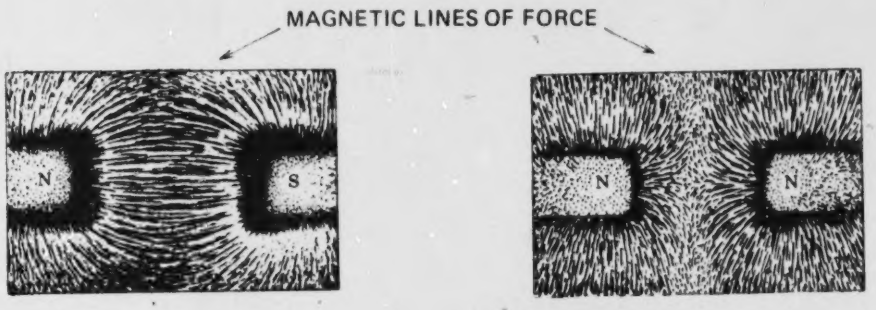
Magnetic lines of force around a bar magnet, as shown by iron filings.

Below is a diagram of the lines of force.



Magnetic lines of force cannot be seen.

Below are more pictures of iron filings, showing the magnetic lines of force between two *like* and two *unlike* poles.



UNLIKE POLES ATTRACT. *LIKE POLES REPEL.*

Another name for lines of force is *lines of magnetic flux.* A magnetic field is also called a *magnetic flux.*

MAGNETIC LINES OF FORCE RULES –

a. They never cross each other.
b. They leave a magnet at its north pole, travel around the magnet, and enter the magnet at its south pole.
c. There are no insulators against magnetism. The lines of force will pass through anything, but will always take the path of least resistance.

ASSIGNMENT:

1. Magnetic lines of force go from the _____ pole to the _____ pole of a magnet.

2. Magnetic lines of force _____ be seen.
(can, may, cannot)

3. What is another name for lines of force?

_____

4. All the magnetic lines together are called _____

a. rules
b. north poles
c. magnetic flux
d. resistance

5. Magnetic lines of force _____ cross each other.
(often, sometimes, never)

6. There are _____ insulators against magnetism.
(very many, a few, no)

Magnetic Induction **Lesson 4**

OBJECTIVE:

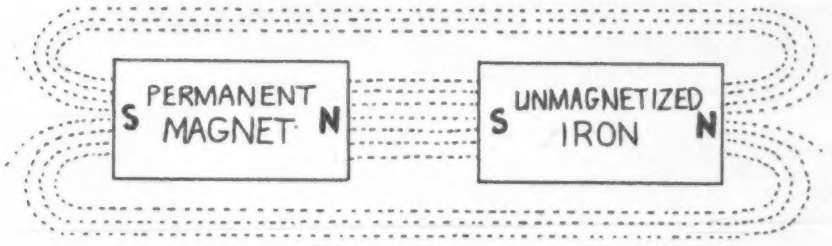
When you have completed this lesson you will know what magnetic induction is.

VOCABULARY:

induction (in-duk'-shən) – making something into a temporary magnet by placing it near a magnet.

INFORMATION:

If you have a piece of unmagnetized iron and you place it near a permanent magnet, the lines of force from the magnet will go out and around and through the unmagnetized iron.



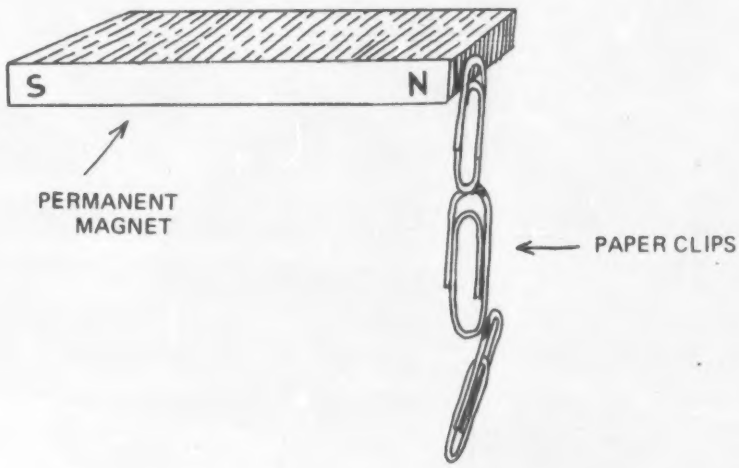
MAGNETIC INDUCTION

The lines of force from the permanent magnet make the unmagnetized iron into a magnet. This action is known as *magnetic induction*. The iron becomes magnetized.

Another example: Take some paper clips and a permanent magnet. Place one paper clip on the magnet. It will be held by the magnet. Now touch the other paper clips with the first one. You will see that other paper clips are picked up by the first. The first paper clip has become a temporary magnet.

If the permanent magnet is strong enough, it will magnetize several clips in this way.

If you carefully lift the first clip away from the magnet, what do you think will happen? The other clips will drop off. The clips were only *temporary* magnets.



Example of Magnetic Induction

ASSIGNMENT:

1. When lines of force from a permanent magnet surround a piece of metal and make it into a magnet, this is known as

   _____.

2. Write in your own words about an example of magnetic induction.

UNIT V – MAGNETISM

Electromagnetism **Lesson 5**

OBJECTIVE:

When you have completed this lesson you will know that electricity can produce magnetism. You will know what an electromagnet is.

VOCABULARY:

electromagnet (i-lek′-trō-mag′nit) – a piece of iron with wire wound around it. It becomes a magnet when electric current moves through the wire.

coil (koil) – a wire turned around and around something, with all the turns in the same direction.

core (kôr) – something in the center of a thing.

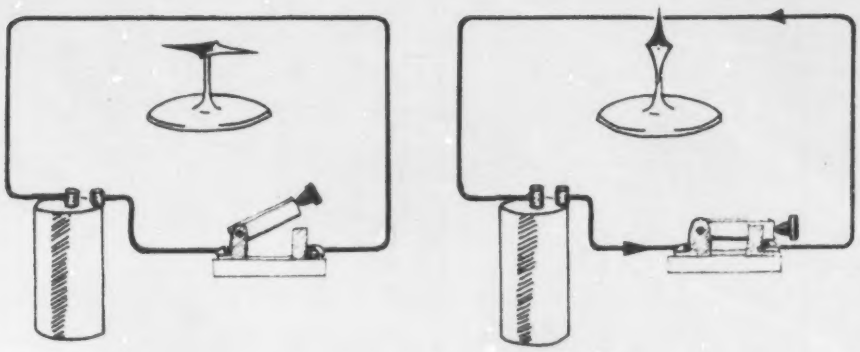
surround (sə-round′) – be all around, on all sides.

collapse (kə-laps′) – fall in suddenly.

INFORMATION:

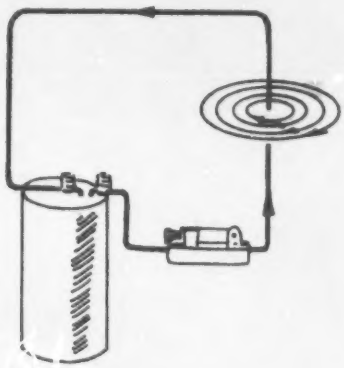
We know now that magnets have magnetic fields around them.

Wires with electricity flowing through them also have magnetic fields around them. Look at this circuit. When there is no electric current, the compass needle is pointing one way. When the switch is closed, the needle swings and points another way. There must be a magnetic field to make the needle turn.

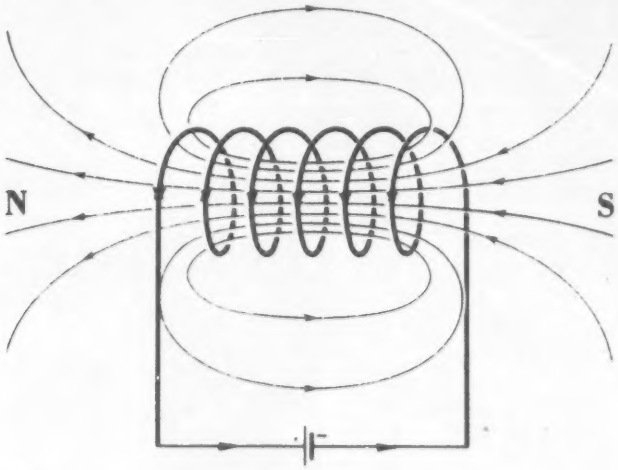


An electric current produces a magnetic field.

The magnetic field goes in circles all around the wire.



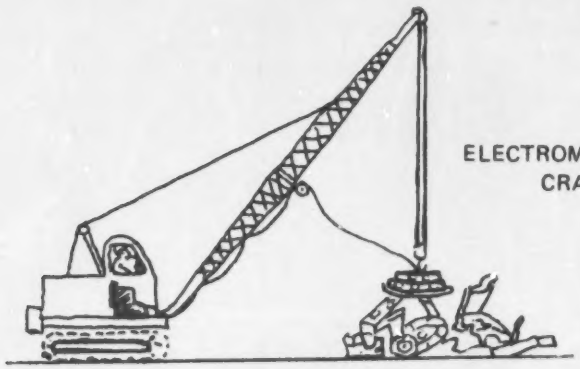
We can make the magentic field much stronger by making a *coil* out of the wire.



Making the wire into a coil makes the coil act like a bar magnet.

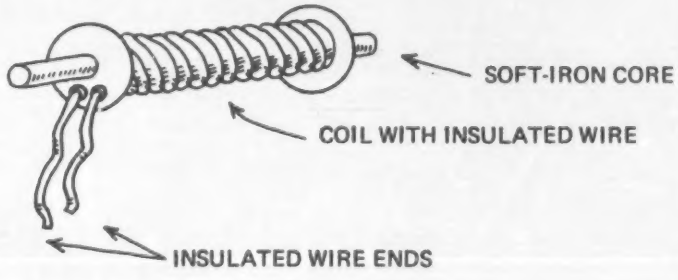
With a coil of wire and a piece or iron, we can make an *electromagnet*.

Electromagnets operate tiny door-bells and switches, all kinds of motors, great magnetic cranes, and many many other things.



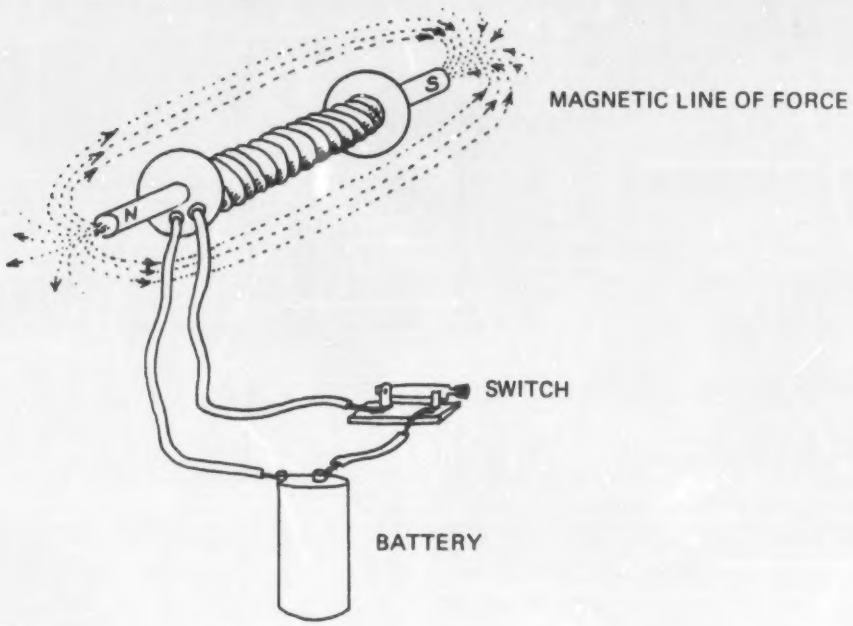
An electromagnetic crane is a large electromagnet. This crane is used to pick up junk metal and carry it to some other place. When the electricity is turned off, the junk metal drops.

An electromagnet is made by making a coil of insulated wire, and inserting a soft-iron *core* in the coil. See below.



Parts of an Electromagnet

If you connect a source of electricity to the wires, electric current will flow through the wires. *Magnetic lines of force* will surround the coil and go through the soft core. The soft iron core will then become a temporary magnet by induction. See next picture.



When you open the switch, the magnetism stops. The lines of force collapse.

The following lessons will tell more about electromagnets.

ASSIGNMENT:

1. What two things can produce a magnetic field?

   1. _____

   2. _____

2. What four things do you need to make an electromagnet?

   1. _____

   2. _____

   3. _____

   4. _____

3. What surrounds the coil when electric current flows through the wire?

   _____ _____ _____ _____

4. The soft-iron core becomes a _____ magnet when electricity flows through the coil.

5. When the switch is opened, the magnetism _____.

   (gets stronger, gets weaker, stops)

6. With your teacher's help, make a list of 10 things that use electromagnets.

Making a Simple Electromagnet **Lesson 6**

OBJECTIVE:

When you have completed this lesson, you will be able to make a simple electromagnet.

VOCABULARY:

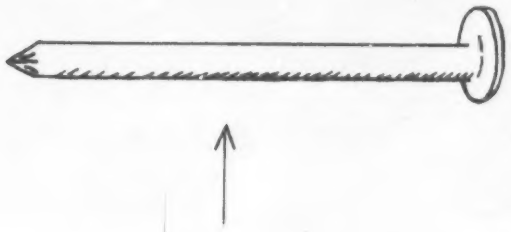
connect (kə-nekt') – join one thing to another.

core (kôr) – the piece of iron that the wire is wound around in an electromagnet.

wound – twisted around many times.

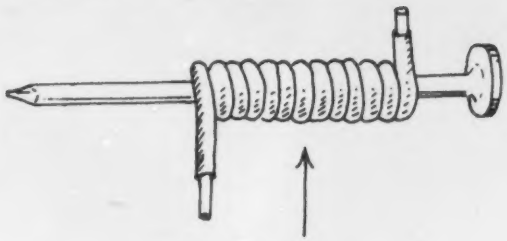
INFORMATION:

An electromagnet can be made using an iron nail. The nail will be the core of the electromagnet.



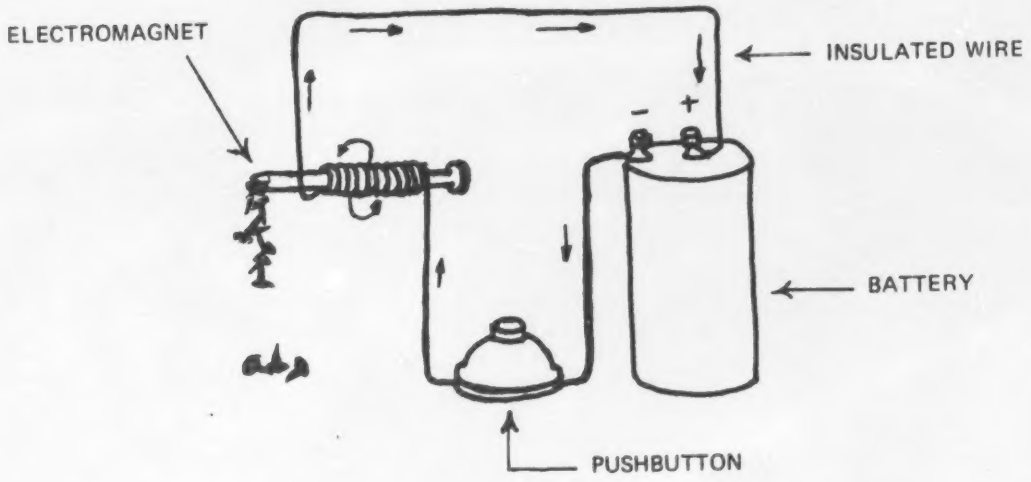
Iron Nail

Insulated wire is wound around the nail.



Nail with Insulated Wire

When a battery is connected to the wires, the nail will become a magnet. Use a knife switch or pushbutton to turn the current on and off.



Simple Electromagnet

ASSIGNMENT:

1. For the nail to become a magnet, an electric _____ must go through the wire.

   a. insulation
   b. crane
   c. current
   d. core

2. _____ wire is wound around the nail.

   a. Magnetic
   b. Bare
   c. Insulated
   d. Iron

3. An electromagnet is a _____ magnet.

   a. permanent
   b. natural
   c. large
   d. temporary

UNIT V – MAGNETISM

How an Electromagnet Operates a Door Bell **Lesson 7**

OBJECTIVE:

When you have completed this lesson, you will be able to describe how an electromagnet makes a door bell operate.

VOCABULARY:

operate (op′-ə-rāt) – work properly; keep something working.
instant (in′-stənt) – a moment; a very, very short bit of time.
vibrate (vī′-brāt) – to move back and forth very fast.

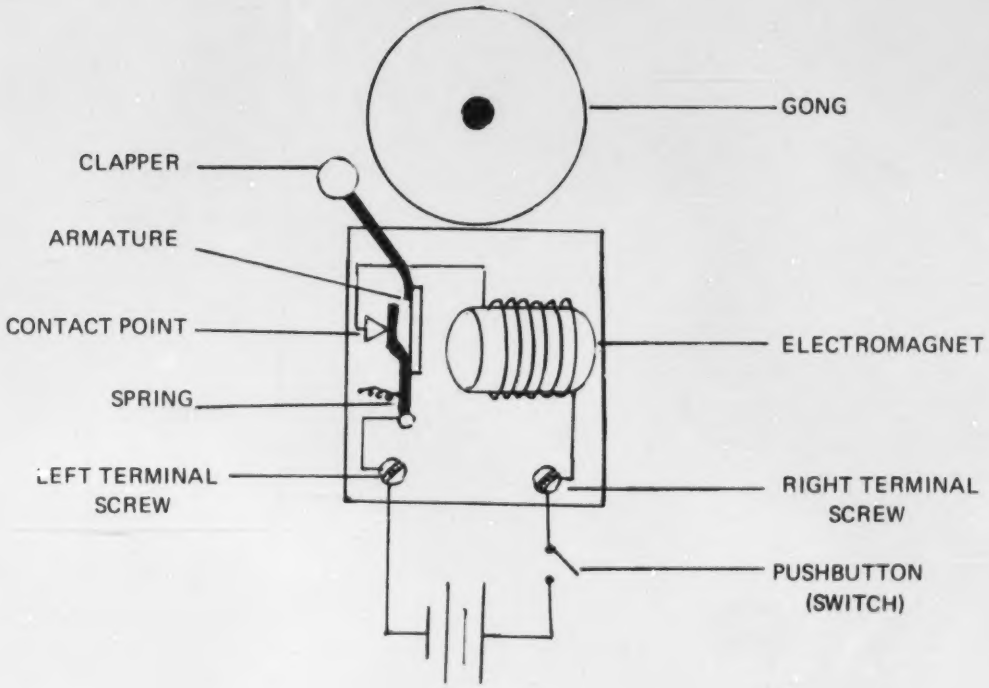
INFORMATION:

Study the pictures on the following pages and you will learn how a door bell operates by an electromagnet.

REMEMBER –

A doorbell operates with an electromagnet. Study the next two pages to learn how the bell works.

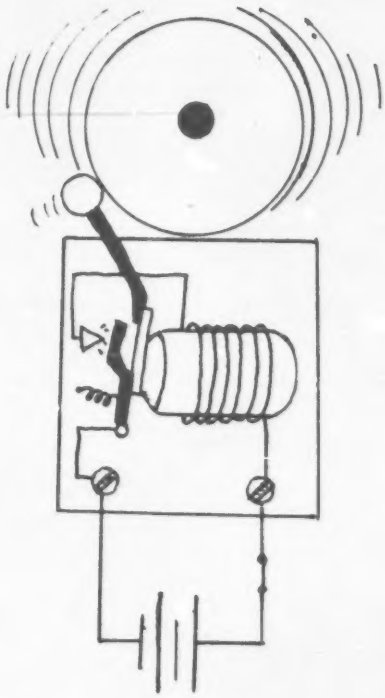
The parts of a bell are shown below. The switch is open; there is no electric current.



What symbol shows that the switch is open?

With your pencil, trace the path that the electrons will take at the instant the switch is closed.

This is how the bell works:



You press the pushbutton.

The switch is closed and electric current moves through the circuit.

The electromagnet pulls the armature to it.

The clapper hits the gong. The gong makes a noise.

The contact point is now open.

Electric current stops. The electromagnet lets the armature go.

The spring pulls the armature back.

The contact point closes.

Electric current moves again through the circuit.

The clapper vibrates back and forth, hitting the gong each time.

The bell stops ringing when you take your finger off the pushbutton. This opens the switch.

ASSIGNMENT:

1. True or False?

_____ a. A door bell operates with an electromagnet.

_____ b. The clapper vibrates when the switch is closed.

_____ c. The contact point opens and closes when the door bell operates.

_____ d. The door bell will operate only when the switch is open.

2. Draw the bell on page 165 and label the parts.

3. Draw the bell on page 166. Describe how the bell operates.